

CLAIMS

What is claimed is:

- Sup 14*
1. A method to stabilize high aspect ratio, post-etch lithographic feature against collapse, the method comprising the steps of:
- 3 (a) coating a substrate with a substantially organic underlayer;
- 4 (b) coating said underlayer with a photoresist comprising materials that form a stable,
- 5 etch-resistant, non-volatile oxide;
- 6 (c) imagewise exposing said photoresist to radiation;
- 7 (d) developing an image in said photoresist;
- 8 (e) transferring said image through said underlayer into said substrate thus forming a
- 9 high aspect ratio resist image; and
- 10 (f) treating said high aspect ratio resist image with a chemically-reducing plasma.

- 1 2. A method to stabilize high aspect ratio, post-etch lithographic feature against collapse, according to claim 1, wherein said photoresist comprises an element capable of forming a stable, etch-resistant, non-volatile oxide selected from the group consisting of silicon, phosphorous, germanium, aluminum, and boron.

- 1 3. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein said bilayer resist comprises:
3 an organic underlayer formed on said substrate; and
4 a photoresist comprising materials that form a stable, etch-resistant, non-volatile oxide
5 formed on said underlayer.

- 1 4. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 1, wherein transferring said image comprises etching wherein
3 said etching comprises passivating chemistry.

- 1 5. A method to stabilize high aspect ratio, post-etch lithographic images against collapse, according to claim 3, wherein passivating chemistry comprises any process that
3 generates hygroscopic moieties.

- 1 6. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 3, wherein passivating chemistry comprises an SO₂ and O₂
3 containing plasma.
- 1 7. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said chemically-reducing plasma comprises
3 hydrogen.
- 1 8. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said chemically-reducing plasma comprises a
3 hydrogen-generating species.
- 1 9. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said underlayer comprises an organic material
3 selected from the group consisting of tuned polymers, novolacs, and low-k dielectrics.
- 1 10. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said underlayer comprises an organic material
3 essentially comprising carbon, hydrogen, and oxygen.
- 1 11. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said photoresist comprises a polymer having acid-
3 cleavable moieties bound thereto.
- 1 12. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said photoresist comprises a polymer formed by
3 polymerizing one or more monomers selected from the group consisting of acrylate,
4 methacrylate, hydroxystyrene optionally substituted with C₁₋₆-alkyl, C₅₋₂₀ cyclic olefin
5 monomers, and combinations thereof, the polymer having acid-cleavable moieties bound
6 thereto, wherein all such moieties are silylethoxy groups optionally substituted on the ethoxy
7 portion thereof with C₁₋₆-alkyl, phenyl, or benzyl.
- 1 13. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said photoresist comprises a radiation-sensitive acid
3 generator.

1 14. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said radiation comprises electromagnetic radiation or
3 electron beam radiation.

1 15. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said radiation comprises ultraviolet radiation or
3 extreme ultraviolet radiation.

1 16. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein said radiation comprises x-ray radiation.

1 17. A method to stabilize high aspect ratio, post-etch lithographic images against
2 collapse, according to claim 1, wherein transferring said image further comprises forming a
3 reduced critical dimension bilayer resist image.

1 18. The stabilized high aspect ratio, post-etch lithographic image formed according to
2 claim 1.

1 19. The semiconductor device fabricated using the stabilized high aspect ratio image
2 formed according to claim 1.

1 20. A method of fabricating semiconductor devices using a stabilized, high aspect ratio
2 bilayer resist image comprising the steps of:
3 (a) coating a substrate with an organic underlayer;
4 (b) coating said underlayer with a photoresist comprising a material that form a stable,
5 etch-resistant, non-volatile oxide;
6 (c) imagewise exposing said photoresist to radiation;
7 (d) developing an image in said photoresist;
8 (e) transferring said image through said underlayer into said substrate thus forming a
9 high aspect ratio resist image;
10 (f) treating said high aspect ratio resist image with a chemically-reducing plasma;
11 (g) transferring said image into said substrate forming a circuit image; and
12 (h) forming circuit element materials in said circuit image.

1 21. A method of fabricating semiconductor devices using a stabilized, high aspect ratio
2 bilayer resist image, according to claim 20, wherein said circuit element materials comprise
3 materials selected from the group consisting of dielectric, conductor, semiconductor, and
4 doped semiconductor materials.

1 22. The stabilized high aspect ratio, post-etch lithographic image formed according to
2 claim 1, wherein said resist is a trilayer resist.

1 23. The stabilized high aspect ratio, post-etch lithographic image formed according to
2 claim 22, wherein said trilayer resist comprises:
3 an organic resist;
4 an anti-reflective coating;
5 an inorganic hard mask; and
6 a thick organic layer.

1 24. The stabilized high aspect ratio, post-etch lithographic image formed according to
2 claim 23, wherein said hard mask comprises silicon.

1 25. The semiconductor device fabricated using a reduced critical dimension bilayer resist
2 image, according to claim 20.

1 26. The semiconductor device fabricated using a stabilized high aspect ratio, post-etch
2 lithographic image formed according to claim 23.